3 Executive Summary

macplan

2 Mackenzie Aviation System

Area Master Plan Study

Transport Canada
Canadian Air Transportation Administration
Western Region
Civil Aviation Branch

June, 1976

HIGHLIGHTS AND RECOMMENDATIONS

- The aviation demand for facilities and service is expected to double in the 1975 to 1985 time period.

- Existing airports in the macplan area can accommodate increased traffic with some additional facilities.

- Communications and navigational aids are generally adequate, but increased coverage is required in specific areas.

- Air Traffic Services is operating at approximately 70% capacity, but airspace utilization is well below capacity.

- The weather information system is generally adequate, except for a few specific areas.

- Capital requirements identified by route evaluation for the current (1975) time period total approximately $15.4 million.

- Capital requirements identified by route evaluation for the future (1985) time period total approximately $5.1 million.

- Program implementation for additional facilities and services should be allocated on a route basis.

- Civil Aviation Planning Division should update this plan bi-annually using current data and forecasts, and a complete update be undertaken every five years to revalidate conclusions.

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1 *INTRODUCTION*

Requirement for Study

There is a close relationship between air transport and the development of the North. The accelerated exploration and development of petroleum, natural gas, minerals and other natural resources, coupled with a proposed Mackenzie valley natural gas pipeline, focused attention on the need for improved air transportation in this very large and underdevloped region of Canada. The extreme high cost and lead time necessary to establish airport and aeronautical facilities, along with an assessment of environmental and socio-economic implications further pointed to the need for advance notice to ensure an orderly development of the air transportation system in the North. In order for Transport Canada to make decisions regarding the future requirements for facilities and services in this vast area the Mackenzie Aviation System Area Master Plan was developed.

Definition

An Area Master Plan is a Regional study of the aviation system which permits safe and efficient air transport between airports. An Area Master Plan is undertaken for a specific geographical area, and studies the future requirements of the following components of the aviation system:

- the airside part of the airport
- the en route navigation system
- the electronic and visual approach and landing aids
- the communication system in support of air traffic control and flight advisory services
- weather services and related facilities

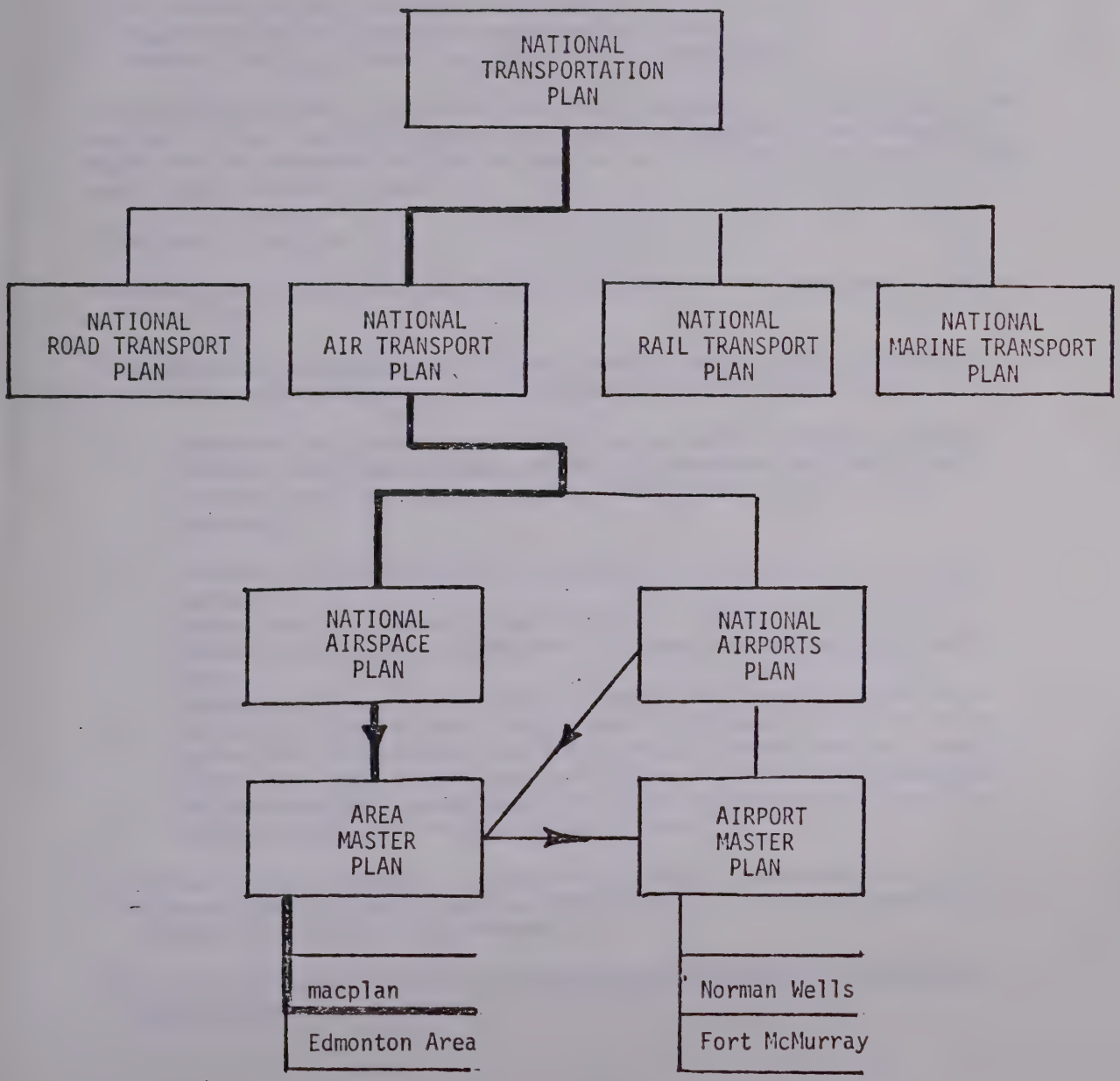
The relationship of macplan to the total transportation planning process is shown on Figure 1.

Project Team Concept

The Study was accomplished under the Project Team concept with representation from all fields of interest. The team consisted of personnel with expertise in aircraft and flight operations, aviation planning, airport planning, telecommunications, air traffic control, meteorology, economics and forecasting, and financial administration, with appropriate administrative, clerical, graphic and stenographical support. The consultant firm of McNeal, Hildebrand and Associates Ltd was retained in the final stage of the Study to assist the team in compilation of the Study data and the production of the main report.

Figure 1.1

Relationship of macplan to Other Planning Processes



Adapted from Figure 1.1-2, *National Planning for Airports* (Ottawa, 1974), and Exhibit VI, "The National Perspective (Technological Plans)," a booklet of CATA planning processes.

The Area

The macplan study area was outlined to include three significant development sub-areas:

A - Northern Alberta (Athabasca tar sands)
B - Mackenzie Valley (proposed gas pipeline route)
C - Western Arctic (mineral and petroleum exploration)

The macplan area was broken down for study purposes into nine Regions on the basis of a relatively large settlement and airport in each Region which form an economic hub for activities in the surrounding area. These Regions are shown on Figure 2.

Objectives of macplan

The objectives of the macplan Study, as stated in the Management Charter, are as follows:

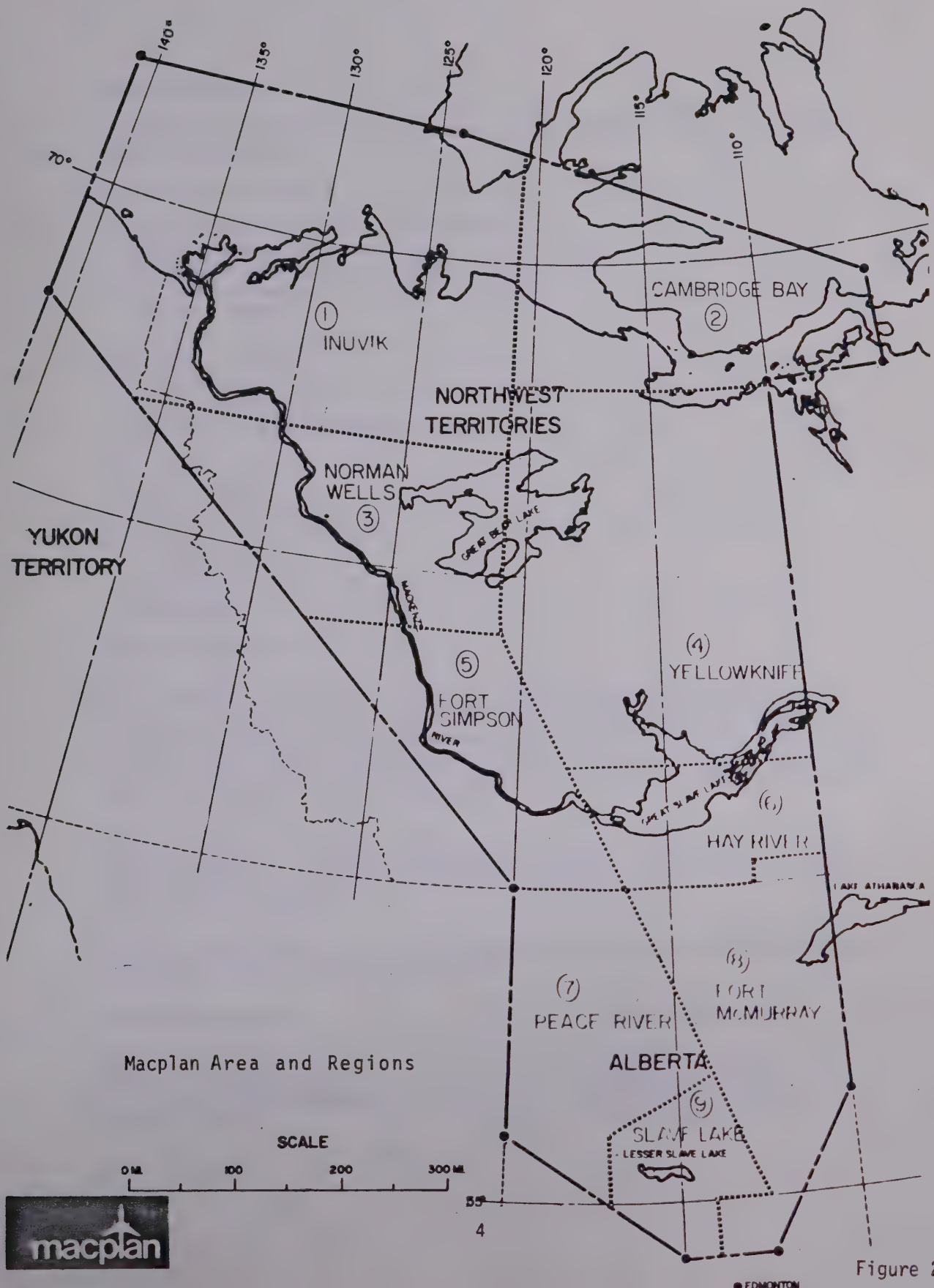
1 *To conceive, develop, and produce a comprehensive plan of development to 1985 for the Mackenzie Area and Western Arctic which will:*

   a) *Recommend an optimum system of airways and air routes including communication facilities, air traffic services and facilities, en route and terminal navigation facilities and AES advisory services.*

   b) *Determine roles and general locations for a system of airports including:*
   - *future traffic demands at each site*
   - *recommendations for improvement to terminal approach and landing aids*
   - *recommendations with respect to runway configurations and class*
   - *the suitability of the site to meet the future role in terms of gross land requirements for air terminal, apron, surface transportation and support services facilities and commercial development*
   - *the constraints imposed upon the future development of the site by socio-economic and environmental factors.*

2 *Further to the findings in Objective 1 to make recommendations on alternatives for development to 1995 which will allow a flexible response to changing requirements.*

3 *To broadly identify costs and revenues associated with recommended developments.*



Macplan Area and Regions

macplan

Figure 2

Macplan Reports

In addition to this Executive Summary, the Project Team has produced the following reports.

Main Report - Volume 1

- Introduction and Study Perspective
- Socio-economic Factors
- Surface Transportation System
- Air Transportation
- Aviation Demand

Main Report - Volume 2

- Aviation Sub-systems
- System Evaluation
- Conclusions and Recommendations

Technical Reports

- Civil Aviation
- Statistics and Forecasts
- Airports
- Telecommunications
- Air Traffic Services
- Meteorology

The Basic Methodology

The methodology selected to meet the Study objectives was a systems approach. The systems approach allowed the project team to structure the problem by reducing the macplan aviation system into its key sub-systems and examining each of these in depth. Each of the sub-systems after analysis was aggregated from simple to complex tasks into a "building block" process to rejoin the total system.

The key sub-systems should reflect the demand and supply sides of the aviation system. By comparing demand with supply, the system problems and constraints could then be easily identified for a further analysis of the system capacity.

The major sub-systems of the aviation system considered, reflecting demand and supply factors, were the following:

Demand Sub-systems	Supply Sub-systems
Socio-economic	Airports
Surface Transportation	Telecommunications
Civil Aviation/Aeronautics	Air Traffic Control
Aviation Demand	Meteorology

2 *DEMAND SUB-SYSTEMS*

Socio-economic

The demographic review of northern Alberta and the District of Mackenzie within the macplan area revealed that the area has a low population density with most people living in the large settlements. The labour force participation rate is also relatively low. The large adolescent population and increasing enrolment in schools should be a factor when considering a future labour force for participation in the economic development of the North.

The economic sector review of activity in the macplan area indicated that the area has potential for slow steady growth in a number of sectors. Development will take place at a slower rate due to the high costs associated with northern opportunities. The economic rate of return, therefore, must be relatively higher to the private sector due to the inherent risks of northern businesses. This means economic development in the macplan area will likely require government support in many areas of the economy. Government now plays a vital role in the economy, and it is expected this role will continue to be important in the future development of the North.

The settlement profiles and the hierarchical settlement patterns indicated that the macplan area has a primary resource industry economy. Strong government administration influences are noted in many settlements. The regional hub centres have economic links with other hub centres in the macplan area, particularly Inuvik, Yellowknife, and Hay River. It can also be seen that economic links are dominant between all the nine macplan regional hub centres and Edmonton. There is little evidence that strong links exist between the various non-hub communities in a region, and it is expected that this "hub-spoke" type pattern will continue.

Surface Transportation

The railways will have an increasing role in the macplan area as mineral and other resource developments proceed to the production phase. Major construction projects such as the Athabasca tar sand extraction plants and the Mackenzie valley pipeline will use the railway to freight heavy construction material to Fort McMurray or Hay River over the next ten-year period.

Truck transportation in the macplan area will maintain its present limited share of carrying freight within the system in the next five to ten years. With improvements to the existing highway network, and the development of new highways in the macplan area, truck transport can be expected to play an increasing role in the future total transport system.

Water transportation has traditionally been the principal mode for low-value high-volume commodities. It is expected that with expansion of the highway system the transportation market share for water transport will decrease. All-weather roads with truck transport on a year-round basis will reduce the cost of inventory now being experienced in the North.

Civil Aviation/Aeronautics

It is the air vehicle which transports people and goods within the aviation system, thereby creating the demand for aviation facilities and services. The demand varies from a small single-engine aircraft on a local VFR flight, to an air carrier aircraft on a scheduled IFR flight. Figure 3 shows an aviation demand profile for a typical scheduled air carrier operation.

There are four basic types of users in the macplan area: private, corporate, government, and air carrier.

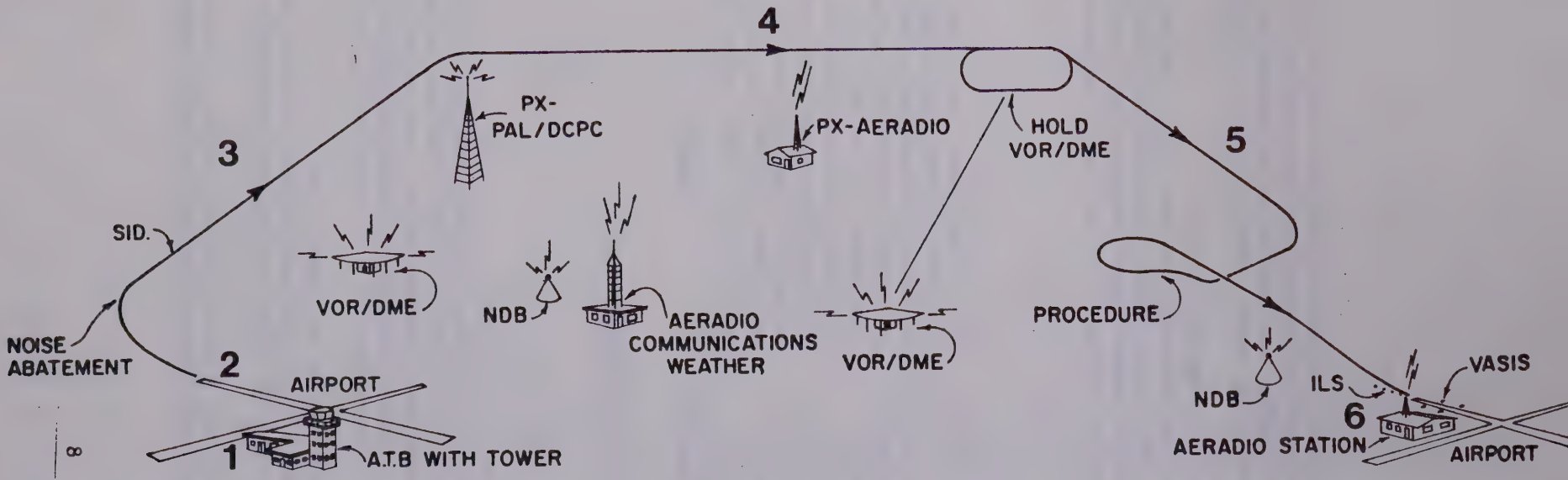
It is estimated there are 570 licensed pilots based in the macplan area, which will increase to about 725 licensed pilots by 1985. It is estimated that in 1974 1700 aircraft were using aviation facilities in the macplan area, which should increase to 3000 aircraft by 1985. There are 35 commercial air carriers which have Air Transport Committee authority to operate air services in the macplan area. It is expected that aircraft technology will change aircraft characteristics so that replacement aircraft will have increased performance and productivity.

Aviation Demand

Station Activity - Current

Yellowknife ranked first in terms of mainline enplaned passengers, followed by Fort McMurray, Inuvik and Hay River. Fort McMurray experienced a six-fold increase from 1970 to 1974, while Inuvik, Cambridge Bay, Yellowknife and Fort Simpson doubled in passenger traffic. Norman Wells, Hay River and Peace River experienced growth rates that nearly doubled their air passenger traffic. Edmonton was the dominant station on an origin-destination basis. There is no evidence of strong intra-community links, however, Yellowknife is the highest volume centre for intra-macplan area passenger traffic. There is little evidence of air passenger links between Northwest Territories and northern Alberta centres.

Enplaned cargo statistics showed Yellowknife ranked first, followed by Inuvik. Inuvik showed the largest increase from 1970 to 1974, where cargo volume more than doubled. Cargo volumes showed wide fluctuations. Deplaned northbound cargo volumes are normally twice southbound volumes.



1 Pre-Flight Preparation
- Civil Aeronautics
- Telecommunications
- Atmospheric Environment Service
- Telecom/Air Traffic Services

2 Take-Off
- Civil Aeronautics
- ATS/Telecom
- Airports

3 Departure & Climb
- Civil Aeronautics
- Telecom
- ATS

4 En Route
- Civil Aeronautics
- Telecom/AES
- ATS

5 Descent & Approach
- Civil Aeronautics
- Telecom/AES
- ATS

6 Land & Post Flight
- Civil Aeronautics
- Telecom
- Airports

Figure 3.0

AIRCRAFT REQUIREMENT / DEMAND PROFILE

Yellowknife, which experienced steady growth from 1970 to 1974, ranked first in enplaned mail. Mail volumes at other centres showed fluctuations.

The total mainline scheduled departing flights in the macplan area in 1974 was 7102. Yellowknife ranked first, followed by Fort McMurray, Norman Wells, Fort Smith, Hay River, Inuvik and Peace River.

Aviation demand for facilities and services is best measured in terms of aircraft movements. Aircraft movement statistics are not available for all macplan sites. Only eighteen sites have historical time-series data, therefore a special survey had to be conducted to yield information on a greater number of sites. Table 1 lists total aircraft movements for the top nine airports in the macplan area for 1974.

Table 1

Total Aircraft Movements - 1974

Rank	Airport	Movements	Remarks
1	Inuvik	44 577	More than 2.5 times 1970 volume
2	Yellowknife	44 414	More than 2 times 1970 volume
3	Fort McMurray	28 202	Three times 1970 volume
4	Peace River	21 209	Only 4% growth from 1970 volume
5	Slave Lake	19 174	24% growth from 1970 volume
6	Hay River	18 833	Two times 1970 volume
7	Norman Wells	16 324	Less than 2 times 1970 volume
8	Fort Simpson	3 875	Airport Construction during 1974: 1973 was 2 times 1970 volume
9	Cambridge Bay	3 478	33% growth from 1970 volume

System Activity - Current

Aircraft movement flow data was not available and had to be developed. This was in two steps - air traffic surveys were conducted, and then the data was converted to annual flows and allocated to routes in the macplan area. Two air traffic surveys were conducted, in June, 1974, and in February, 1975, each recording both IFR and VFR traffic.

The VFR survey recorded all traffic in radio communications with Aeradio stations, showing direction and origin and destination of each flight. The IFR surveys were conducted using flight strips from the Edmonton Area Control Centre. The IFR traffic was segregated into low- and high-level traffic.

The results of the two surveys were expanded to produce annual air traffic volumes on an origin-destination basis. These volumes were then allocated to routes indicating flow volumes between stations. Table 2 ranks the top ten VFR traffic routes in 1974, on a total two-way flow basis.

Table 2

Top Ten VFR Traffic Routes - 1974

Rank	Route Segment	Itinerant Movements
1	Inuvik-Tuktoyaktuk	4320
2	Norman Wells-Fort Good Hope	2630
3	Edmonton-Peace River	1810
4	Fort Good Hope-Inuvik	1760
5	Fort McMurray-Fort Chipewyan	1660
6	Fort Simpson-Wrigley	1570
7	Edmonton-Fort McMurray	1180
8	Peace River-High Level	1160
9	Fort Chipewyan-Fort Smith	1150
10	Norman Wells-Wrigley	1130

Table 3 ranks the top ten IFR traffic routes in 1974, by direction of flight.

Table 3

Top Ten IFR Traffic Routes - 1974

Rank	Route Segment	Itinerant Movements*
1	Edmonton-Fort McMurray	4890
2	Fort McMurray-Edmonton	4200
3	Edmonton-High Level	4040
4	High Level-Edmonton	3880
5	High Level-Fort Simpson	3010
6	Fort Simpson-High Level	2800
7	Wrigley-Fort Simpson	2420
8	Fort Simpson-Wrigley	2370
9	Inuvik-Norman Wells	2370
10	Norman Wells-Inuvk	2360

* Excluding overflights

Station Activity - Future

Forecasts have been developed for 1985 and trend projections to 1995. Wherever possible and appropriate, growth scenarios were presented for the low, medium and high forecast ranges.

Using the medium growth scenario as most probable, Yellowknife is expected to increase from 77 000 enplaned/deplaned passengers in 1975 to 188 500 in 1985, an increase of 2.5 times. Fort McMurray is expected to increase to three times the 1974 volume.

Forecasts and projections of aircraft movements by station were developed for itinerant and local air movements. The following table uses the medium scenario to forecast 1985 total aircraft movements for the top five airports.

Table 4

Total Aircraft Movements - 1985

Rank	Airport	Movements	Remarks
1	Inuvik	96 000	Two times 1974 volume
2	Yellowknife	94 600	Two times 1974 volume
3	Slave Lake	45 700	Greater than twice 1974 volume
4	Norman Wells	45 000	Almost three-fold increase
5	Fort McMurray	44 800	Approximately 150% increase

Similar growth is anticipated at other macplan sites.

System Activity - Future

Based on flow data and station forecasts, system flow forecasts for both IFR and VFR traffic were developed for 1985. The following two tables indicate the top ten routes in terms of VFR and IFR traffic volumes.

Table 5

Top Ten VFR Traffic Routes - 1985

Rank	Route Segment	Itinerant Movements
1(1)*	Inuvik-Tuktoyaktuk	8700
2(2)	Norman Wells-Fort Good Hope	7180
3(6)	Fort Simpson-Wrigley	3900
4(4)	Fort Good Hope-Inuvik	3500
5(10)	Norman Wells-Wrigley	3080
6(7)	Edmonton-Fort McMurray	2800
7(5)	Fort McMurray-Fort Chipewyan	2540
8(11)	Hay River-Yellowknife	2360
9(3)	Edmonton-Peace River	2240
10(12)	Nicholson Peninsula-Sachs Harbour	2120

Table 6

Top Ten IFR Traffic Routes - 1985

Rank	Route Segment	Itinerant Movements
1(1)*	Edmonton-Fort McMurray	11600
2(2)	Fort McMurray-Edmonton	9950
3(5)	High Level-Fort Simpson	8670
4(6)	Fort Simpson-High Level	8060
5(3)	Edmonton-High Level	6990
6(7)	Wrigley-Fort Simpson	6970
7(8)	Fort Simpson-Wrigley	6830
8(4)	High Level-Edmonton	6710
9(9)	Inuvik-Norman Wells	4790
10(10)	Norman Wells-Inuvik	4770

* 1975 rank in parentheses

The VFR and IFR route flow forecasts for 1985 show the macplan area routes which will experience the greatest aviation demand, and therefore justify future aviation facilities and services first.

SUPPLY SUB-SYSTEMS

Airports

Within the macplan area, nine airports have been selected as hub airports to smaller feeder airports in the surrounding macplan Region. These nine "Regional" airports are:

Inuvik (Region 1)
Cambridge Bay (Region 2)
Norman Wells (Region 3)
Yellowknife (Region 4)
Fort Simpson (Region 5)
Hay River (Region 6)
Peace River (Region 7)
Fort McMurray (Region 8)
Slave Lake (Region 9)

There are eight Transport Canada ARTA Category A airports (runway length 6 000 ft or more) in the macplan area:

Inuvik	Hay River	Cambridge Bay
Norman Wells	Fort McMurray	Fort Simpson
Yellowknife	Fort Smith	

There are four Category B airports (runway lengths between 5 000 ft and 6 000 ft):

Coppermine	Peace River
Tuktoyaktuk	Slave Lake

There are 3 Transport Canada, 8 military, 14 Government of Alberta and 22 Government of the Northwest Territories airports in Category C. (runways from 3 000 to 5 000 feet).

By 1985 it is expected that Peace River and Slave Lake airports will be upgraded to Category A. A number of Category C airports will probably be upgraded to Category B status. These include:

High Level	Holman Island
Fort Chipewyan	Sachs Harbour
Fort Providence	Lac La Biche

An analysis of gross land requirements for both airside and groundside activities was conducted. The analysis considered 41 sites in the macplan area with a present gross land area of some 31 000 acres. Airports in Category A account for 10 411 acres, over one-third of the total land area. Category B airports account for 4 997 acres, and the remaining 32 sites in Category C, about 15 550 acres. It is estimated by 1985 the total land requirement will be about 32 176 acres. By 1995 the gross land area estimate is 32 426 acres, only a 5% increase over the current figure.

Airport safety height zoning problems may be encountered when considering future development, however the only Transport Canada airport with problems is Norman Wells. There are nine other airports with zoning problems.

An analysis of Noise Exposure Forecast contours for the major airports indicates the only Transport Canada airport that could be a problem is Yellowknife. Slave Lake airport may adversely affect town development.

An analysis of runway capacity did not identify any sites where additional runways would be required. After 1985 the runway lengths at Slave Lake and Peace River may have to be increased in order to accept the most likely aircraft types in use, but not due to runway capacity limitations. A number of runway surfaces require improvement. It was also identified by ARTA that runway lengths in the future should be restricted to encourage operators to use STOL-type aircraft, in lieu of large CATA expenditures for runway length extensions.

Surveys and runway capacity calculations indicate that taxiway constraints are affecting airport capacity. Delays are experienced at Inuvik, Fort McMurray, Yellowknife and Peace River due to inadequate taxiway systems.

A survey of six airport operators indicated serious ramp congestion problems at Inuvik, Norman Wells, Yellowknife, Fort Simpson, Fort Chipewyan and Holman Island. Increased ramp area, ramp management, and mobile refueling are solutions for the congestion problem.

A comparison of airport lighting inventory and Arctic airport standards revealed a number of sites requiring improved lighting facilities. It is recommended that the lighting be upgraded at these sites.

Fixed refueling has been identified as a cause of ramp congestion. Mobile trucks would free more ramp area for parking. The availability of turbine fuel should be expanded as set out in the Arctic airports program.

There is no serious lack of airport emergency equipment.

A survey revealed that there is not adequate aircraft servicing, particularly with respect to hangar space and qualified personnel. It is recommended that provision be made to assist northern aircraft service companies in upgrading their facilities and the qualifications of their service personnel.

Airspace conflicts with neighbouring seaplane bases or airstrips were identified at Inuvik, Yellowknife and Fort McMurray. VFR flight corridors are not being used effectively, and more control is recommended to ensure their use.

Telecommunications

Communications

The common carrier leased landlines consist of a weather teletype network, the ADIS circuit and the ATC circuits. The teletype network operates at 100 words per minute, and is now near capacity. Delays of up to two hours have been experienced obtaining weather from Toronto central computer facilities. The problems are access to the central computer and transmitting only the relevant parts of the sequences. These are broad problems, beyond the scope of the macplan Study. No problems were noted in the Automatic Data Interchange System circuit, except with the teletype printer. The study identified that ATC circuit 400 is at capacity. It is recommended that a new circuit to Fort McMurray be established on the microwave system to increase the capacity of the dedicated voice line.

There are 19 Aeradio stations in the macplan area. It is recommended that an additional station be established at Slave Lake.

Geographic coverage of VHF air/ground communications signal reception was examined at altitudes of 5 000, 10 000 and 18 000 ft, which showed some gaps. It is recommended that VHF communication be established to permit reception on airways at minimum en route altitudes.

The Arctic airports program plans to install VHF Unicom facilities at 13 macplan sites. This should assist in closing some of the low-altitude gaps, but gaps still remain on five routes.

Peripheral facilities are divided into two groups: DCPC PAL for direct pilot/controller communication, and Aeradio PAL to extend Aeradio coverage for flight advisory services. It is recommended that the Norman Wells DCPC PAL be relocated to Oscar Mountain, and an additional PAL be installed on Mount Sittichni for coverage. It is recommended that Aeradio PAL stations be installed at the Taglu, Port Radium and Bear Rock CNT sites, and the Tar Island AGT site.

Navigation Aids

Non-directional beacon coverage was analysed and is generally available throughout the macplan area. It is recommended that NDB coverage be increased at Port Radium and Sachs Harbour to fill small voids.

There are six VHF omni-directional range stations commissioned in the macplan area, with three more to be operational within two years. An analysis of VOR signal coverages at altitudes of 5 000, 10 000 and 18 000 feet shows inadequate coverage at 5 000 feet, some significant route gaps at 10 000 feet, and a small gap in the signal coverage at 18 000 feet. A VOR station is recommended at Hay River, which would provide signal coverage at 18 000 feet. VOR coverage in northeast Alberta is lacking, and a VOR station is recommended for Fort McMurray to provide coverage.

Distance Measuring Equipment (DME) has similar range and siting constraints as VOR facilities.

It is recommended that all Aeradio stations in the macplan area be equipped with VHF Direction Finding (VHF/DF) equipment.

The three types of approach aids used in the macplan area are the Instrument Landing System (ILS), the NDB for an Automatic Direction Finding (ADF) approach, and the VOR for a VOR approach.

ILSs are installed at Inuvik, Yellowknife, Hay River and Fort McMurray By 1985 ILSs will be required at Cambridge Bay, Norman Wells, Fort Simpson, Fort Smith, Peace River and Slave Lake.

Less than half of the airports in the macplan area are equipped with NDBs. It is recommended that a number of additional sites, particularly Category C Arctic airports, require NDB facilities.

Airports served with VOR facilities are Inuvik, Cambridge Bay, Norman Wells, Fort Simpson, Yellowknife, High Level and Peace River. A VOR is urgently required at Fort McMurray.

Secondary radar at Edmonton provides coverage in the extreme southern part of the macplan area. At an altitude of 25 000 feet the coverage is limited to a radius of 180 miles north of Edmonton. Radar coverage will be extended with the JETS program linking military radar units at Beaver Lodge and Cold Lake with Edmonton radar. Coverage would then include Peace River and Fort McMurray. It is suggested that after 1985 radar units will be required at Yellowknife and Inuvik for air traffic separation.

Capacity Analysis

Based on Arctic airports program criteria and CATA's objectives, policies and standards, the telecommunications requirements for 1975 and 1985 were developed for each macplan site in relation to current and future aviation demand.

Air Traffic Services

Controlled airspace in the macplan area includes control areas, airways, control zones, and control area extensions.

The control areas in high-level airspace are sub-divided into the Northern Control Area above Flight Level 230 and the Southern Control Area above 18 000 ft asl, both within the Edmonton Flight Information Region. Control areas in low-level airspace include all airspace from 700 feet above the surface of the earth to 18 000 ft asl within the confines of low-level airways.

There are nine low-frequency airways (formed by NDBs), and six Victor, or VHF, airways (formed by VORs). As the VOR program is implemented, Victor airways will be increased in number and length.

Control zones are designated around fourteen macplan airports, ten of which also have control area extensions.

In the macplan area there are four procedural Control Sectors and two radar Control Sectors. These Control Sectors are designated as Sectors 2, 3, 3A, 4, 6A and 6D. Present staffing and equipment at the Edmonton Area Control Centre is designed to handle 90 percent of the highest expected peak period air traffic at any given time. It is estimated that the Control Sectors, on average, are now reaching levels of about 70 percent of the system design capacity.

The en route capacity for a route segment is difficult to quantify because such variables as levels of air traffic, control capability, safety requirements, complexity of traffic patterns and navigation facilities cannot be accurately taken into account in the capacity analysis. However, if it can be assumed that the airway network is a simple system, and that a 120-nautical mile separation standard is maintained throughout the total macplan airway system, a theoretical estimate of en route airway capacity can be attempted.

Based on 3392 miles of low-level airways in the macplan area, it is estimated that the capacity is 336 aircraft at any one time. Similarly, with 5040 miles of high-level airways, it is estimated that the capacity is 672 aircraft, in each case considering all useable altitudes.

Regarding Area Control Centre capacity, it is reported that Control Sectors 3 and 3A will reach design capacity by 1977. In order to meet expected future air traffic control demands, it is planned to enlarge Sector 3 to include control to Tuktoyaktuk from Inuvik. High-level Control Sectors 4 and 4A are reported to be at capacity, and preferential routings have been made mandatory to increase the Sectors' capacity to meet traffic demands. Additional VOR/DME and DCPC PAL facilities would also assist in reducing Sector limitations. Discrete ATC interphone landlines

would also reduce air traffic control delays and improve the system capacity.

Meteorology

In the macplan area there are 27 weather observing and reporting stations operated by Transport/AES, DND/USAF, and private contract organizations. Additional weather data is obtained from Alberta Forest Service and Agriculture Canada, but due to teletype circuit capacity limitations the information may not be relayed in station weather sequences. The format of Forestry weather does not conform to aviation hourly reports.

There are two weather Forecast Offices with responsibility in the macplan area. These are the Edmonton and Arctic Forecast Offices, and each produces forecasts applicable to the Study area.

There are two types of Weather Offices. Presentation offices are the first type, staffed by trained AES technicians who are qualified to brief aircrew using facsimile maps, forecasts and teletype traffic. The second type are Preflight Weather Information Stations (PFWIS) staffed by Transport Canada Aeradio operators who provide weather information based on AES forecasts and teletype traffic.

Analysis of aviation weather requirements conducted from air traffic surveys and surveys of Aeradio and meteorological stations indicated 14 sites in northern Alberta and 17 sites in the Northwest Territories from which weather information is required. A specific site analysis was conducted for these suggested sites, which indicated two sites in northern Alberta and eight sites in the Northwest Territories lack sufficient weather information.

SYSTEM EVALUATION

An attempt was made to evaluate the macplan aviation system using a cost-effectiveness technique. An analysis was conducted for each of the nine macplan Regions and the facilities and services within each of the Regions. The evaluation proved to be site-oriented, the alternatives were not always mutually exclusive, and the weighting criteria applied was not equitable between factors.

Criteria were then developed for establishing system alternatives based on problem identification from the analyses conducted. The following were identified as system problems.

VFR Flight Plan processing	Helicopter traffic
Terminal airspace control	Seaplane facilities
VFR flight safety	Joint use of navigation facilities
NOTAM information	ATC clearance readback
En route separation	Establishing SIDs and STARs
Gravel runways	Communication and navigation gaps
Jet fuel availability	Weather teletype congestion
Apron size	Lack of weather coverage
Fixed refueling facilities	Private aeronautical facilities

It was difficult to analyze these eighteen system problems and establish alternatives which were mutually exclusive. In most cases only two alternatives were possible: to do nothing (ie, maintain the *status quo)*, or to install or provide the facility or service. It was also determined that the problem was directly linked to safety requirements. If the traffic demands for installing or providing a facility or service meet CATA or Arctic airports criteria standards, the facility or service was warranted.

The evaluation technique used, therefore, was a simple priority system where aviation system facilities and services were included if traffic levels were sufficient to install or provide the facility or service for safety reasons.

The evaluation was conducted first by sub-system component, by macplan Region, and then by routes (or route-pairs) in the macplan aviation system. The evaluation was conducted for both the 1975 and 1985 (current and future) time periods.

Current System

The sub-system evaluation analysis identified the following 1975 costs by sub-systems:

Airports	$16 635 000
Telecommunications	4 335 000
Air Traffic Services	70 000
Meteorology	60 000
Total	$21 100 000

The top thirty-four routes were considered for inclusion in the route evaluation. Both VFR and IFR air traffic volumes were examined, and the routes were arranged in order of total traffic volume, thereby indicating priority. It was assumed that a relationship between traffic volume and safety requirements existed, therefore, the higher traffic volume routes should be considered higher in facilities and services allocation.

The total capital cost for facilities and services required for the top thirty-four routes is $15 414 000.

Future System

In terms of 1975 dollars, the 1985 capital cost requirements for aviation facilities and services by sub-system is as follows:

Airports	$ 1 605 000
Telecommunications	2 818 000
Air Traffic Services	1 800 000
Meteorology	182 000
Total	$ 6 405 000

On a route evaluation basis, whereby the required facilities and services are assigned to one or more of the top thirty-four routes considered, the 1985 capital requirement is $5 057 000.

Table 7 provides a summary of the recommended facilities and services by sub-system, for the current and future time periods. Figures 4 and 5 summarize the routes evaluated, indicating the cost of implementing the required facilities and services for each route, and its rank for the current and future time periods, respectively.

IMPLEMENTATION PROGRAM

In terms of an implementation program, the system evaluation procedure selected arranges a priority system. It is assumed that the higher the traffic demand, the more urgent the safety requirements. Therefore, the higher traffic volume routes in the macplan area should be allocated priority in having the required facilities and services installed or provided. However, it is unreasonable to expect that all facilities and services for all routes can be provided, due to normal budget constraints. The implementation program can therefore be planned within annual budget constraints. The cost to improve the total aviation system is not exclusively Transport Canada's responsibility. Many of the aviation facilities and services identified in the Study are the responsibility of other federal government agencies, the Government of Alberta, the Government of the Northwest Territories, and private organizations. Each participant in the aviation system would have to participate in the contribution to the total annual budget. These could be partly financed by a user-cost method, with Transport Canada as the coordinator of the implementation program.

The implementation procedure would be to select the highest volume route and install and provide the necessary facilities and services as identi-

fied in the current route evaluation. Subsequent routes would be selected on a traffic volume priority until the annual budget was exhausted. In the following fiscal year the procedure would resume. Ideally, by 1985, all the facility and service requirements identified in the current route evaluation would have been completed, and the entire procedure to implement the facilities and services identified in the 1985 (future) route evaluation could be started.

It should be noted, however, that the implementation program is not rigid. The annual budget amount could vary from year to year, and the route priorities could also change. The implementation program, nevertheless, does provide a structure to program current and future aviation facilities and services.

Table 7

Sub-system Evaluation - Summary

	Airports		Telecommunications		Air Traffic Services		Meteorology	
Region 1	1975	1985	1975	1985	1975	1985	1975	1985
Inuvik	1) Construct parallel taxiway half runway length 2) Establish ramp management 3) Use fuel tenders	1) Limit airport use for design aircraft 2) Encourage private operators to improve aircraft servicing	1) Commission VOR/DME 2) Establish Aeradio/PAI	1) Install Terminal Radar	1) Design VFR corridor to Arctic Coast 2) Develop SIDs & STARs 3) Develop air routes to pipeline construction	1) Upgrade air route to airway Inuvik to Sachs Harbour	1) Establish 24 hour presentation service	
Tuktoyaktuk	1) Move runway lighting controls to suitable location 2) Install A/VASIS 3) First response fire truck	1) Restrict airport for design aircraft 2) Establish Civil fuel supply	1) Relocate Aeradio transmitter receiver antenna 2) Install VHF/DF in Aeradio		1) Upgrade air route to airway to Inuvik			1) Establish preflight weather station
Aklavik	1) Improve runway 2) Construct apron and taxiway 3) Install runway lighting	1) Limit airport use to design aircraft	1) Install VHF/ Unicom	1) Install NDB	1) Establish air route to Inuvik	1) Upgrade air route to airway		1) Establish Arctic C weather service
Fort McPherson	1) Install runway lighting	1) Limit airport to design aircraft	1) Install NDB 2) Install VHF/ Unicom		1) Establish air route to Inuvik	1) Upgrade air route to airway	1) Arctic C weather	
Arctic Red River	1) Construct - runway - taxiway - apron 2) Install runway lighting	1) Limit airport use to design aircraft	1) Install NDB 2) Install VHF/ Unicom					1) Establish Arctic C weather service
Paulatuk		1) Existing runway is 45° out of wind consider reconstruction	1) Increase NDB coverage 2) Install VHF Unicom			1) Extend air route from Paulatuk to Cape Parry	1) Establish Arctic C weather	
Sachs Harbour		1) Limit airport to design aircraft						
Region 2								
Cambridge Bay	1) Pave runway		1) Install VHF/DF	1) Install ILS			1) Establish preflight weather station	
Holman Island	1) Construct runway 2) Relocate buildings to ensure airport zoning 3) Install runway lighting		1) Install VHF/ Unicom			1) Design air route Holman Island to Sachs Harbour	1) Establish Arctic C weather	
Region 3								
Norman Wells	1) Increase apron size 2) Use fuel tenders 3) Improve seaplane docking 4) Install High Intensity approach lights		1) Install ILS 2) Install VHF/ DF 3) Relocate DCPC/ PAL to Oscar Mtn. 4) Establish Aeradio/PAL at Bear Rock		1) Develop air route Norman Wells to Fort Franklin	1) Establish Control Tower	1) Establish preflight weather service	1) Establish weather presentation service
Fort Norman	1) Improve runway surface		1) Install low power NDB 2) Install VHF/ Unicom					1) Establish Arctic C weather
Fort Good Hope	1) Lengthen and resurface runway	1) Improve runway surface	1) VOR/DME	1) VHF/DF				
Fort Franklin		1) Gravel runway surface	1) VHF/Unicom					

Table 7

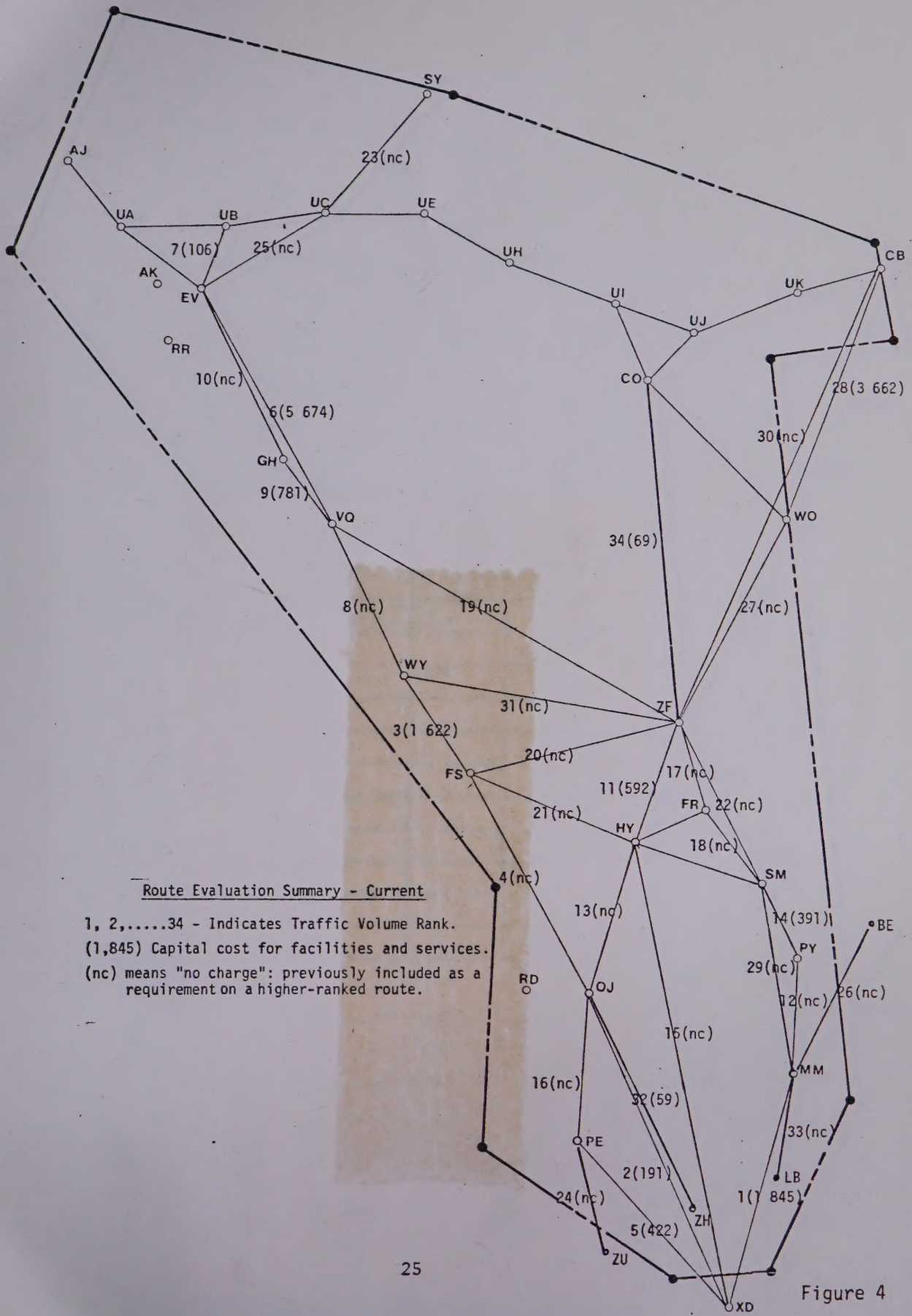
Sub-system Evaluation - Summary

	Airports		Telecommunications		Air Traffic Services		Meteorology	
	1975	1985	1975	1985	1975	1985	1975	1985
Region 4								
Yellowknife	1) Construct holding bay 2) Designate helipad		1) Install two NDBs for holding 2) Aeradio/PAL for Fort Radium 3) Establish discrete frequency to prevent interference HY and ZF	1) Terminal Radar	1) More effective use of VFR Corridors 2) Exception to the cruise altitude true vs. magnetic tracks	1) Air route to Coppermine 2) VOR airway to Hay River 3) VOR airway to Fort Smith		
Coppermine			1) Move Aeradio to airport	1) VOR/DME			1) Move weather station to airport	
Snowdrift	1) Install runway lighting		1) Install NDB 2) VHF/Unicom				1) Establish Arctic C weather	
Sawmill Bay				1) Install NDB 2) VHF/Unicom				1) Install MARS
Lac La Martre		1) Construct gravel runway 2) Install runway lighting		1) Install NDB 2) VHF/Unicom				1) Establish Arctic C weather
Port Radium		1) Install runway lighting		1) Install VHF/Unicom				
Rae Lakes		1) Construct gravel runway		1) Install NDB 2) VHF/Unicom				
Rae/Edzo				1) Install NDB 2) VHF/Unicom				
Fort Reliance				1) VHF/Unicom				
Contwoyto Lake								1) MARS
Region 5								
Fort Simpson	1) Increase apron size 2) Use mobile refuelling 3) Improve seaplane dock 4) A/VASIS		1) ILS 2) VHF/DF				1) Preflight weather	1) Presentation weather service
Wrigley	1) Resurface runway		1) VOR/DME	1) VHF/DF		1) Victor Airway to Yellowknife		
Region 6								
Hay River	1) Negotiate seaplane docking with N.T.C.L.		1) VOR/DME 2) VHF/DF 3) Discrete VHF frequency (interference with ZF)		1) Renumber airways Blue 3 and Blue 42	1) VOR airway to Fort Smith 2) VOR airway to Fort Simpson 3) ATC control tower	1) Preflight weather	1) Presentation weather service
Fort Providence	1) Install runway lighting		1) Install low power NDB 2) VHF/Unicom					
Pine Point		1) Runway lighting						
Region 7								
Peace River	1) Improve taxiway system or holding Bay		1) ILS			1) VOR airway to Slave Lake 2) Control tower		
High Level	1) Increase apron size 2) A/VASIS		1) DCPC/PAL	1) VHF/DF	1) See Telecom for PAL	1) Air route to Rainbow Lake		
Fort Vermilion							1) Establish Arctic C weather service	
Rainbow Lake							1) Establish Arctic C weather service	
Spirit River		1) Install runway lighting						

Table 7

Sub-system Evaluation - Summary

	Airports		Telecommunications		Air Traffic Services		Meteorology	
	1975	1985	1975	1985	1975	1985	1975	1985
Region 8								
Fort McMurray	1) Parallel taxiway half runway length 2) Increase apron size 3) Establish mobile fuel service		1) VOR/DME 2) VHF/DF 3) Aeradio/PAL 4) ATC Landline		1) Temporary ATC tower 2) VOR airway to Edmonton	1) Develop air route to Peace River 2) Establish permanent control tower	1) Establish preflight weather service	1) Establish weather presentation service
Fort Smith	1) Designate helipad area 2) Establish mobile refuelling		1) VOR/DME 2) ATC landline	1) ILS 2) VHF/DF			1) Preflight weather service	
Fort Chipewyan	1) Improve apron		1) Develop communications to Uranium City 2) ATC landline	1) VHF/DF				
Athabasca		1) Improve runway 2) Install runway lighting	1) Aeradio/PAL to Slave Lake					
Region 9								
Slave Lake	1) Develop noise abatement	1) Develop approach light system 2) A/VASIS	1) DCPC/PAL for ATC 2) Establish aeradio station 3) Aeradio/PAL to Whitecourt	1) VOR/DME 2) ILS	1) Develop low level airway to Edmonton	1) Air route to Whitecourt	1) Preflight weather station	
Whitecourt	1) New airport under development 2) To be paved in 1977 3) Install runway lighting		1) VOR/DME 2) Move Aeradio to new airport	1) VHF/DF				
Wabasca		1) Install runway lighting						
Barrhead		1) Lengthen and resurface runway 2) Install lighting						
High Prairie		1) Install runway lighting						



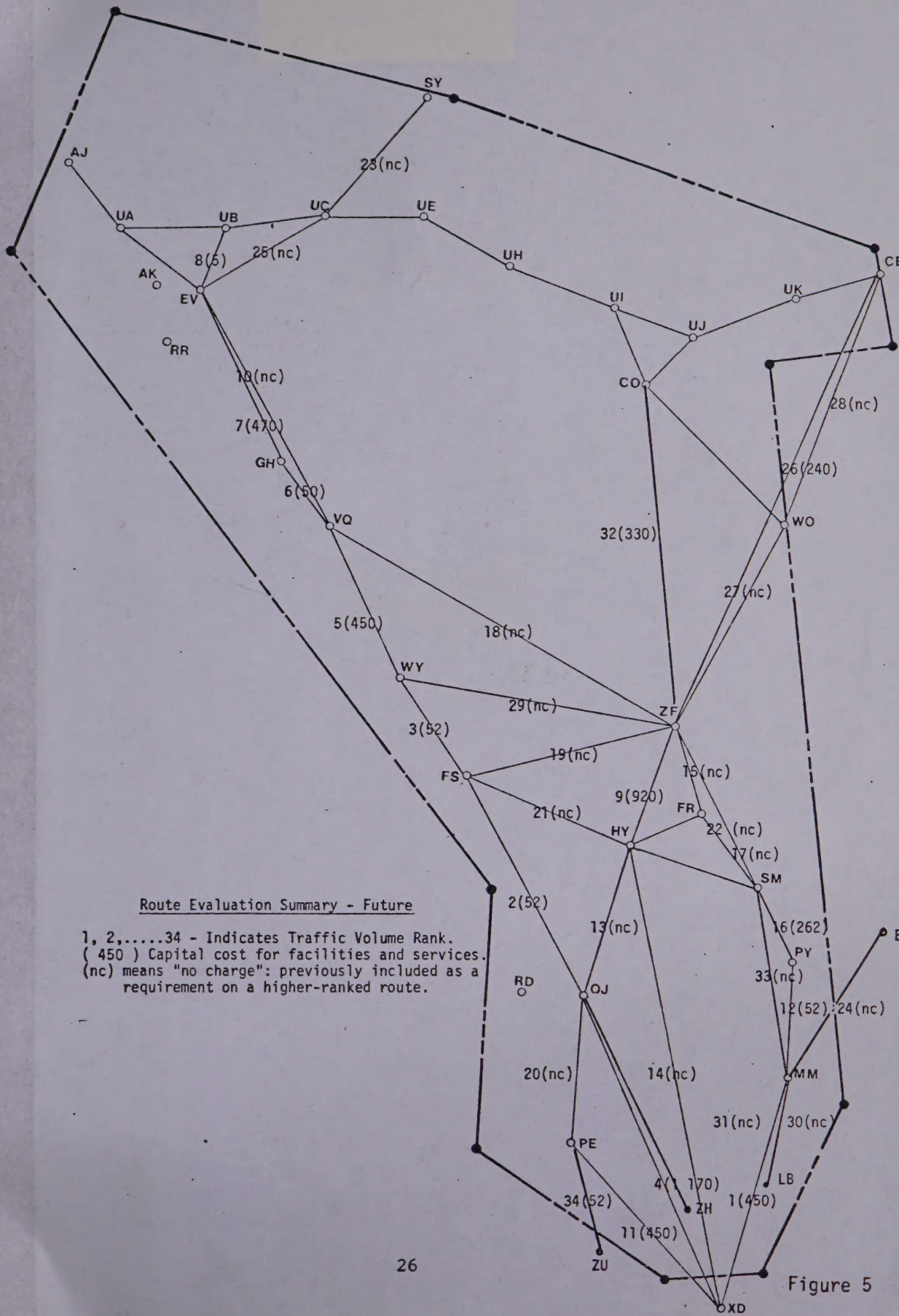
Route Evaluation Summary - Current

1, 2,.....34 - Indicates Traffic Volume Rank.

(1,845) Capital cost for facilities and services.

(nc) means "no charge": previously included as a requirement on a higher-ranked route.

Figure 4



Route Evaluation Summary - Future

1, 2,.....34 - Indicates Traffic Volume Rank.
(450) Capital cost for facilities and services.
(nc) means "no charge": previously included as a requirement on a higher-ranked route.

Figure 5